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Symposium: Immune function in environmental extremes—an introduction

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CASTELLANI, J. W. Immune function in environmental extremes—an introduction. *Med. Sci. Sports Exerc.*, Vol. 34, No. 12, pp. 2002–2003, 2002. Physiological systems are influenced by many stressors. Arguably, the most important physiological cue could be the environment in which the organism is exposed, because if responses or adaptations cannot occur or are blunted upon various environmental exposures (e.g., heat, cold, hypoxia, gravity), then the health and well-being of an organism is jeopardized. Humans do not live in a vacuum; thus, we are constantly faced with turning physiological control systems on and off to deal with environmental extremes.

The impact of environmental extremes has typically focused on the cardiovascular, respiratory, and musculoskeletal systems. However, despite the emergence of exercise immunology in the past decade (see (6) for extensive review), the effect of various environmental stressors on the human immune system has not been examined to the same extent (7). Figure 1 presents many of the factors that could have an impact on the immune system. Most of the early work in exercise immunology focused on the “event,” (i.e., how exercise intensity and duration interact to influence the immune system). For example, there is a fairly large body of literature that has examined whether immune function is suppressed for several hours after strenuous exercise (3). This concept of the “open window” has been used to correlate laboratory with epidemiological findings. More recently, factors inherent to the individual have been studied, including age (1) and nutrition (4,5). Always present but not systematically studied is the environment.

Why is it important to understand the effect of environmental extremes on the immune system? One reason is that if strenuous exercise does indeed increase the risk for opportunistic microorganisms to establish themselves during the open window period, then exposure to environmental extremes could modulate this response. A question one could ask is, “Does the immune system after a marathon respond differently

if the runners compete in a hot, cold, or high-altitude environment?” Another reason is that humans may be dealing with new threats to health when exposed to different extremes. For example (Fig. 2), Nickerson et al. (2) demonstrated that virulence was greater in salmonella that were exposed to microgravity conditions, compared with normal gravity ($1 \times g$). Thus, even if our immune systems remain intact during long-duration space travel, we could still experience an increased risk of infection from pathogenic microorganisms. However, more problematic is that our immune systems could potentially be compromised by exposure to $0 \times g$; thus, the infection risk may reach the point at which long-term space travel (e.g., to Mars and back) may not be recommended.

The purpose of these series of papers, presented at the 2001 Annual Meeting of the American College of Sports Medicine, is to review the current knowledge about the effects of cold, hypoxia, and space travel on the immune system. It is hoped that the reader will gain an appreciation that environmental factors do affect various immune system responses and must be considered when designing and interpreting research studies. The reader should also be cognizant that reported changes in different immune variables are difficult to relate to specific host defense changes and that more research is needed to show definitively that exposure to different environmental extremes does indeed alter susceptibility to various pathogens.

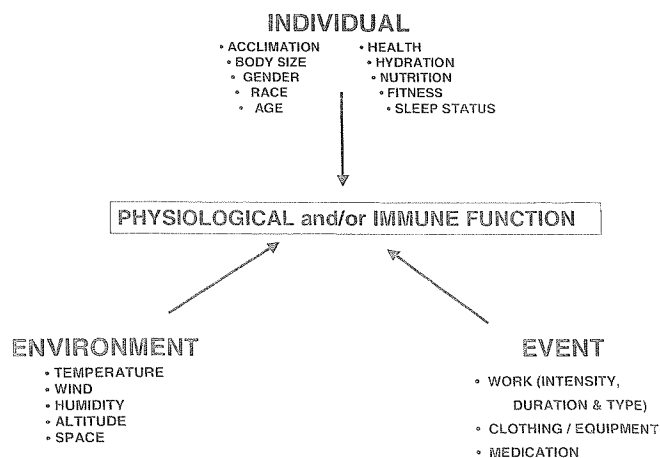


FIGURE 1—Selected individual, event, and environmental factors that affect physiological and immune function.

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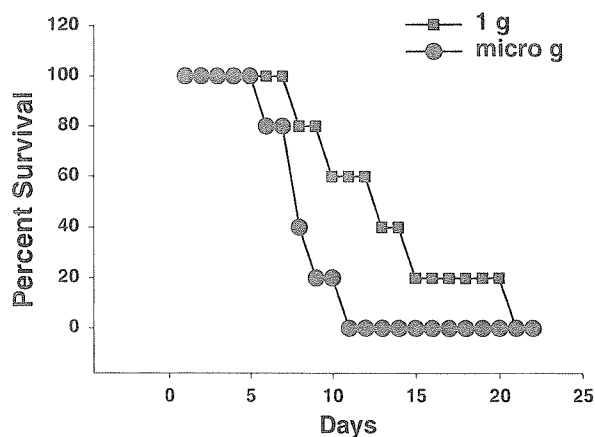
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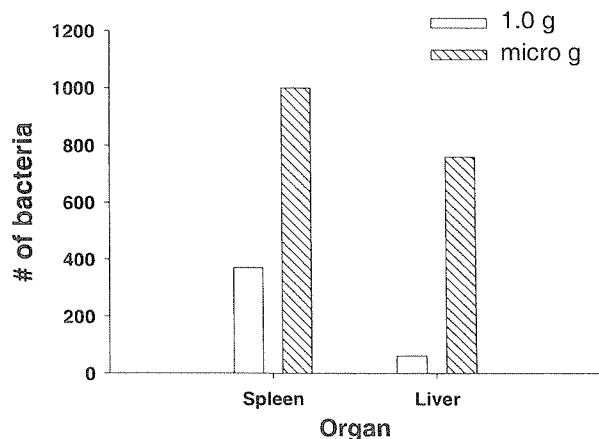


FIGURE 2—A. Percentage survival (days) in rats after injection of *Salmonella typhimurium* grown and cultured in normal earth's gravity ($1 \times g$) or in simulated microgravity conditions (micro g). B. Number of *Salmonella typhimurium* bacterium obtained from rat spleen and liver after being grown and cultured in normal earth's gravity ($1.0 \times g$) or in simulated microgravity (micro g). Graphs redrawn from data of Nickerson et al. (2).

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